

Listing of Claims

1. - 29. (cancelled)

1 30. A system for measuring parameters of a structure, the system comprising
2 a plurality of strain gauges emplaceable on the structure,
3 signal transmission apparatus associated with the plurality of strain
4 gauges for transmitting signals therefrom indicative of measurements by the
5 plurality of strain gauges to computer apparatus for processing signals from the
6 strain gauges,
7 the plurality of strain gauges including at least three strain gauge
8 apparatuses for providing axial strain measurements at each location of one of
9 the at least three strain gauge apparatuses,
10 computer apparatus for receiving signals from the transmitting
11 apparatus indicative of the measurements of the at least three strain gauge
12 apparatuses and for determining, based on said measurements, bending
13 moment of the structure at a location of a plane including the at least three
14 strain gauge apparatuses,
15 temperature measurement apparatus for measuring temperature of
16 the structure at the location of the plurality of strain gauges, and
17 wherein the computer apparatus is programmed to adjust said
18 measurements for temperature changes indicated by the temperature
19 measurement apparatus.

1 31. (new) The system of claim 30 wherein the computer apparatus is
2 programmed to calculate internal pressure of the structure based on strain
3 measurements from the plurality of strain gauges.

1 32. (new) The system of claim 30 wherein the computer apparatus is
2 programmed to calculate bending direction of the structure at said location based on
3 said measurements.

1 33. (new) The system of claim 31 wherein the computer apparatus determines
2 bending moment in real time.

1 34. (new) The system of claim 33 wherein the computer apparatus is
2 programmed to make a plurality of continuous determinations of bending moment in

3 real time.

1 35. (new) The system of claim 31 further comprising encasement material
2 encasing the plurality of strain gauges.

1 36. (new) The system of claim 35 wherein the encasement material comprises
2 insulating material for enhancing uniformity of operation of the plurality of strain
3 gauges during temperature changes.

1 37. (new) The system of claim 35 wherein the encasement material comprises
2 potting material.

1 38. (new) The system of claim 30 further comprising
2 each of the plurality of strain gauges comprises a fiber optic strain
3 gauge.

1 39. (new) The system of claim 30 further comprising
2 display apparatus for displaying to an operator determinations of
3 the computer apparatus.

1 40. (new) The system of claim 30 further comprising
2 alarm apparatus for warning an operator of the system that a
3 maximum allowable stress on the structure has been reached, the computer
4 apparatus programmed to calculate maximum allowable stress and in
5 communication with the alarm apparatus.

6 41. (new) The system of claim 30 wherein the temperature measurement
7 apparatus comprises fiber optic strain gauge apparatus for measuring temperature.

1 42. (new) The system of claim 30 wherein the system includes temperature
2 measurement apparatus for measuring temperature of the structure at the location of
3 the plurality of strain gauges, pressure measurement apparatus for measuring internal
4 pressure of the structure, and weight measurement apparatus for measuring weight
5 of the structure; and the computer apparatus is programmed to receive signals
6 indicative of strain measurements from the plurality of strain gauges, temperature
7 measurements from the temperature measurement apparatus, internal pressure
8 measurements from the pressure measurement apparatus, and weight measurement
9 from the weight measurement apparatus, and the computer apparatus is programmed
10 to determine bending moment of the structure at the location of the plurality of strain

gauges, stresses throughout the structure, maximum stress on the structure, and location of maximum stress on the structure.

43. (new) The system of claim 30 wherein the plurality of strain gauges comprises at least one set of three fiber optic strain gauges including an axial strain gauge for measuring axial stress on the structure, a hoop strain gauge for measuring hoop stress on the structure, and a temperature strain gauge for measuring temperature of the structure.

44. (new) The system of claim 43 wherein the at least one set of three fiber optic strain gauges is four sets spaced at ninety 90 degree intervals around the structure.

45. (new) The system of claim 30 wherein the structure is from the group consisting of riser, subsea riser, lubricator, pipe support structure, tubular string, and lubricator stack.

46. (new) The system of claim 30 further comprising
a protective ring apparatus on the structure adjacent which is located the plurality of strain gauges.

47. (new) The system of claim 46 wherein the protective ring apparatus is two spaced-apart rings between which are located the plurality of strain gauges.

48. (new) The system of claim 46 wherein potting material encapsulates the plurality of strain gauges.

49. (new) The system of claim 30 further comprising
cover apparatus releasably connected to the structure over the plurality of strain gauges.

50. (new) A method for measuring parameters of a structure, the method comprising

measuring parameters of the structure with a system, the system comprising a plurality of strain gauges emplaceable on the structure, signal transmission apparatus associated with the plurality of strain gauges for transmitting signals therefrom indicative of measurements by the plurality of strain gauges to computer apparatus for processing signals from the strain gauges, the plurality of strain gauges including at least three strain gauge apparatuses for providing axial

9 strain measurements at each location of one of the at least three strain gauge
10 apparatuses, computer apparatus for receiving signals from the transmitting apparatus
11 indicative of the measurements of the at least three strain gauge apparatuses and for
12 determining, based on said measurements, bending moment of the structure at a
13 location of a plane including the at least three strain gauge apparatuses, temperature
14 measurement apparatus for measuring temperature of the structure at the location of
15 the plurality of strain gauges, and wherein the computer apparatus is programmed to
16 adjust said measurements for temperature changes indicated by the temperature
17 measurement apparatus, and the computer apparatus is programmed to receive signals
18 indicative of temperature measurements from the temperature measurement
19 apparatus.

1 51. (new) The method of claim 51 wherein the computer apparatus is
2 programmed to calculate internal pressure of the structure based on strain
3 measurements from the plurality of strain gauges, the method further comprising
4 with the computer apparatus, calculating said internal pressure.

1 52. (new) The method of claim 51 wherein the computer apparatus is
2 programmed to calculate bending direction of the structure at said location based on
3 said measurements, the method further comprising
4 with the computer apparatus, calculating said bending direction.

1 53. (new) The method of claim 51 wherein the computer apparatus determines
2 bending moment in real time, the method further comprising
3 with the computer apparatus, determining said bending moment
4 in real time.

1 54. (new) The system of claim 51 wherein the computer apparatus is
2 programmed to make a plurality of continuous determinations of bending moment in
3 real time, the method further comprising
4 with the computer apparatus, making said plurality of continuous
5 determinations in real time.

1 55. (new) The method of claim 51 wherein the computer apparatus is
2 programmed to calculate bending direction of the structure at said location based on
3 said measurements and wherein the system includes pressure measurement apparatus

4 for measuring internal pressure of the structure, and weight measurement apparatus
5 for measuring weight of the structure; and the computer apparatus is programmed to
6 receive signals indicative of strain measurements from the plurality of strain gauges,
7 internal pressure measurements from the pressure measurement apparatus, and
8 weight measurement from the weight measurement apparatus, and the computer
9 apparatus is programmed to determine, in real time, bending moment of the structure
10 at the location of the plurality of strain gauges, stresses throughout the structure,
11 maximum stress on the structure, and location of maximum stress on the structure,
12 the method further comprising

13 with the computer apparatus, calculating in real time said bending
14 direction, said bending moment, said stresses throughout the structure, said
15 maximum stress, and said location of said maximum stress.

1 56. (new) The method of claim 51 wherein the said bending direction, said
2 bending moment, said stresses throughout the structure, said maximum stress, and
3 said location of said maximum stress are displayed on display apparatus.

1 57. (new) A system for measuring parameters of a structure, the system
2 comprising

3 a plurality of strain gauges emplaceable on the structure,
4 signal transmission apparatus associated with the plurality of strain
5 gauges for transmitting signals therefrom indicative of measurements by the
6 plurality of strain gauges to computer apparatus for processing signals from the
7 strain gauges,

8 the plurality of strain gauges including at least three strain gauge
9 apparatuses for providing axial strain measurements at each location of one of
10 the at least three strain gauge apparatuses,

11 computer apparatus for receiving signals from the transmitting
12 apparatus indicative of the measurements of the at least three strain gauge
13 apparatuses and for determining, based on said measurements, bending
14 moment of the structure at a location of a plane including the at least three
15 strain gauge apparatuses,

16 temperature measurement apparatus for measuring temperature of

17 the structure at the location of the plurality of strain gauges,

18 wherein the system includes pressure measurement apparatus for
19 measuring internal pressure of the structure, and weight measurement
20 apparatus for measuring weight of the structure; and the computer apparatus
21 is programmed to receive signals indicative of strain measurements from the
22 plurality of strain gauges, temperature measurements from the temperature
23 measurement apparatus, internal pressure measurements from the pressure
24 measurement apparatus, and weight measurement from the weight
25 measurement apparatus, and the computer apparatus is programmed to
26 determine bending moment of the structure at the location of the plurality of
27 strain gauges, stresses throughout the structure, maximum stress on the
28 structure, and location of maximum stress on the structure.

1 58. (new) A system for measuring parameters of a structure, the system
2 comprising

3 a plurality of strain gauges emplaceable on the structure,
4 signal transmission apparatus associated with the plurality of strain
5 gauges for transmitting signals therefrom indicative of measurements by the
6 plurality of strain gauges to computer apparatus for processing signals from the
7 strain gauges,

8 the plurality of strain gauges including at least three strain gauge
9 apparatuses for providing axial strain measurements at each location of one of
10 the at least three strain gauge apparatuses,

11 computer apparatus for receiving signals from the transmitting
12 apparatus indicative of the measurements of the at least three strain gauge
13 apparatuses and for determining, based on said measurements, bending
14 moment of the structure at a location of a plane including the at least three
15 strain gauge apparatuses,

16 a protective ring apparatus on the structure adjacent which is
17 located the plurality of strain gauges, and

18 wherein the protective ring apparatus is two spaced-apart rings
19 between which are located the plurality of strain gauges.

1 59. (new) A method for measuring parameters of a structure, the method
2 comprising

3 measuring parameters of the structure with a system, the system
4 comprising a plurality of strain gauges emplaceable on the structure, signal
5 transmission apparatus associated with the plurality of strain gauges for
6 transmitting signals therefrom indicative of strain measurements by the plurality
7 of strain gauges to computer apparatus for processing signals from the strain
8 gauges, the plurality of strain gauges including at least three strain gauge
9 apparatuses for providing axial strain measurements at each location of one of
10 the at least three strain gauge apparatuses, and computer apparatus for
11 receiving signals from the transmitting apparatus indicative of the
12 measurements of the at least three strain gauge apparatuses and for
13 determining, based on said measurements, bending moment of the structure at
14 a location of a plane including the at least three strain gauge apparatuses,

15 wherein the computer apparatus is programmed to calculate
16 bending direction of the structure at said location based on said measurements
17 and wherein the system includes temperature measurement apparatus for
18 measuring temperature of the structure at the location of the plurality of strain
19 gauges, pressure measurement apparatus for measuring internal pressure of the
20 structure, and weight measurement apparatus for measuring weight of the
21 structure; and the computer apparatus is programmed to receive signals
22 indicative of strain measurements from the plurality of strain gauges,
23 temperature measurements from the temperature measurement apparatus,
24 internal pressure measurements from the pressure measurement apparatus, and
25 weight measurement from the weight measurement apparatus, and the
26 computer apparatus is programmed to determine, in real time, bending moment
27 of the structure at the location of the plurality of strain gauges, stresses
28 throughout the structure, maximum stress on the structure, and location of
29 maximum stress on the structure, the method further comprising

30 with the computer apparatus, calculating in real time said bending
31 direction, said bending moment, said stresses throughout the structure, said

32 maximum stress, and said location of said maximum stress.

1 60. (new) The method of claim 59 wherein the said bending direction, said
2 bending moment, said stresses throughout the structure, said maximum stress, and
3 said location of said maximum stress are displayed on display apparatus.